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BUREAU OF MINES MINERALS YEARBOOK

Sulfur

UNITED STATES DEPARTMENT OF THE INTERIOR

The statistical data in this volume represents the most comprehensive, verified, domestic and international coverage for 1987 at the time the volume went to press. More recent information can be found in the monthly Sulfur Mineral Industry Surveys obtainable from Publications Distribution, Bureau of Mines, Box 18070, Cochrans Mill Road, Pittsburgh, PA 15236.

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UNITED STATES DEPARTMENT OF THE INTERIOR • Donald Paul Hodel, Secretary

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This publication is a chapter from the current Bureau of Mines Minerals Yearbook, comprising *Volume I, Metals and Minerals; Volume II, Area Reports: Domestic; Volume III, Area Reports: International.* The separate volumes of the Yearbook are sold by the Superintendent of Documents, Washington, D.C. 20402.

Sulfur

By David E. Morse[1]

The United States retained its position as the world's foremost producer and consumer of sulfur. Production and shipments from U.S. Frasch mines, the Nation's major source of discretionary sulfur, decreased because low international prices reduced export opportunities. Although the industry operated well below capacity, shipments by Frasch producers to their major consumer, the domestic phosphate fertilizer industry, increased because exports of fertilizers by U.S. producers were substantially higher than those in 1986.

Production of recovered elemental sulfur, a nondiscretionary byproduct of petroleum refining and natural gas processing, continued to increase, setting an alltime record high; domestic output from this source exceeded the quantity of elemental sulfur produced by any other nation in the world. Shipments of recovered elemental sulfur to domestic consumers were greater than Frasch shipments. For the first time, recovered sulfur exports, primarily from California where sulfur supplies exceed local demands, were higher than Frasch sulfur exports.

Table 1.—Salient sulfur statistics

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1983	1984	1985	1986	1987
United States:					
Production:					
Frasch	3,202	4,193	5,011	4,643	3,202
Recovered[1]	4,955	5,214	5,313	5,316	6,161
Other forms	1,133	1,245	1,285	1,228	1,176
Total	9,290	10,652	11,609	11,087	10,539
Shipments:					
Frasch	4,111	5,001	4,673	4,106	3,610
Recovered[1]	5,041	5,210	5,266	5,756	6,180
Other forms	1,133	1,245	1,285	1,228	1,176
Total	10,285	11,456	11,229	11,134	10,966
Exports, elemental[2]	902	1,334	1,365	1,895	1,342
Imports, elemental	1,695	2,557	2,104	1,347	1,099
Consumption, all forms	10,988	12,679	11,968	10,586	11,223
Stocks, Dec. 31: Producer, Frasch and recovered	2,223	2,419	2,799	2,748	2,316
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$414,210	$546,106	$573,570	$508,512	$396,824
Recovered[1]	384,214	416,878	485,064	533,752	492,136
Other forms	116,255	121,602	123,987	105,639	90,707
Total	914,679	1,084,576	1,182,581	1,147,903	980,677
Exports, elemental[3]	$109,296	$156,067	$189,248	$251,664	$139,431
Imports, elemental[4]	$129,110	$200,129	$199,240	$142,220	$152,096
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$87.24	$94.31	$106.46	$105.22	$89.78
World: Production, all forms (including pyrites)	r49,770	r51,869	54,381	p54,074	e54,221

eEstimated. pPreliminary. rRevised.
[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes exports from the Virgin Islands to foreign countries.
[3]Includes value of exports from the Virgin Islands to foreign countries.
[4]Declared customs valuation.

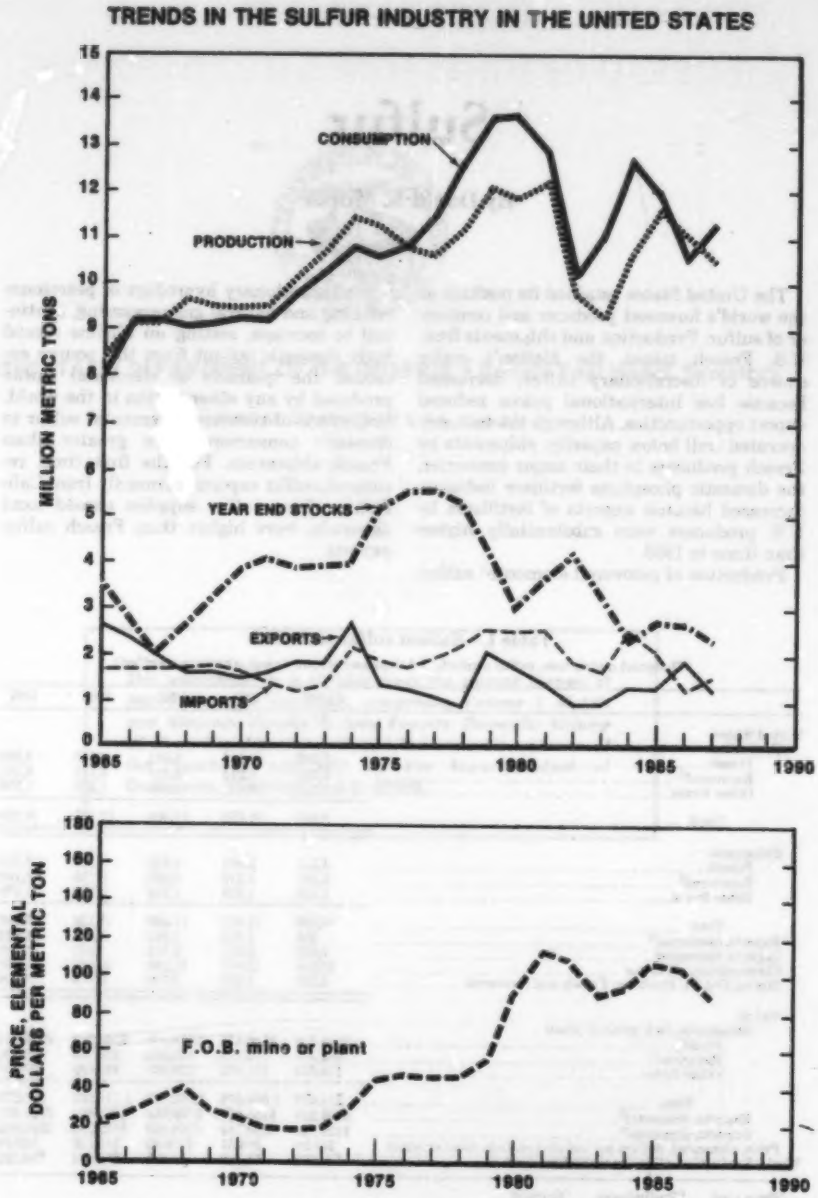

Figure 1.—Trends in the sulfur industry in the United States.

Byproduct sulfuric acid from the Nation's nonferrous smelters and roasters, essentially mandated by laws concerning sulfur dioxide (SO_2) emissions, supplied a significant quantity of sulfuric acid to the domestic merchant acid market. Marketing sulfuric acid continued to be a problem for most producers because smelters were near Western copper mines and not close to large sulfuric acid markets.

Total world production of sulfur in all forms increased over that of 1986; however, mined sulfur and pyrites output were lower. Recovered elemental production increased in Asia, Eastern Europe, and North America, and was slightly less in Western Europe, where declining production from gas plants was nearly offset by increased output from petroleum refineries. Nearly two-thirds of the world's elemental sulfur production came from recovered sources. The quantity of sulfur supplied from these sources was dependent on the world demand for fuels and petroleum products, not on the demand for sulfur.

World consumption increased, especially in the fertilizer sector. Consumption for other industrial uses continued to be pressured by environmental constraints placed on either the products produced or by effluents from the processes. World trade also increased, but the trade patterns were altered significantly because of restricted imports by the U.S.S.R. and by lower international prices. World stocks of elemental sulfur declined by an estimated 700,000 metric tons and contributed to an oversupply condition in the international marketplace.

Domestic Data Coverage.—Domestic production data for sulfur are developed by the Bureau of Mines from four separate, voluntary surveys of U.S. operations. Typical of these surveys is the "Elemental Sulfur" survey. Of the 184 operations to which a survey request was sent, 182 responded, representing 99.91% of the total production shown in tables 1 and 2. The production of the two nonrespondents was estimated using prior production histories adjusted to reflect trends in output of their primary products.

DOMESTIC PRODUCTION

Sulfur is one of the few elements that occur in the native, or elemental, state. It also occurs combined with iron and base metals as sulfide minerals, and with the alkali metals and alkali earths as sulfate minerals. In coal and petroleum, sulfur is found in a variety of complex organosulfur compounds, and in natural gas as hydrogen sulfide (H_2O) gas. Commercial production of sulfur in the United States is accomplished by a variety of methods dictated by the source of sulfur.

Frasch.—Native sulfur associated with the caprocks of salt domes and in sedimentary deposits is mined by the Frasch hot-water method, in which the native sulfur is melted underground and brought to the surface with an airlift. In January 1987, the United States had four Frasch mines operating in Texas and Louisiana. Mines in Louisiana were Freeport Minerals Co. at Garden Island Bay on the Mississippi River Delta and Grand Isle, 7 miles offshore in the Gulf of Mexico. Mines in Texas were Pennzoil Sulphur Co. at Culberson and Texasgulf Inc. at Boling Dome in Wharton County. Texasgulf's Comanche Creek facility in western Texas was idle for the entire year. Freeport continued to rehabilitate its Caminada Pass, LA, property, which had last produced sulfur in 1968. At yearend, the Frasch mining industry was operating at about 65% of capacity.

Frasch sulfur output decreased 841,000 tons from the quantity produced in 1986. Total shipments to domestic and overseas consumers declined by 500,000 tons. Frasch sulfur accounted for 30% of domestic production in 1987, compared with 36% in 1986. Approximately 87% of Frasch sulfur shipments was for domestic consumption, and 13% for export. The total value of Frasch sulfur shipments decreased nearly $122 million.

Recovered.—Production of recovered elemental sulfur, a nondiscretionary byproduct from petroleum refining, natural gas processing, and coking plants, accounted for 59% of the total domestic output of sulfur in all forms, compared with 52% in 1986. Both production and shipments reached alltime-high levels of over 6.16 million tons owing to record-high production from the Nation's petroleum refineries and gas processing plants. Recovered elemental sulfur was produced by 56 companies at 157 plants in 26 States, 1 plant in Puerto Rico, and 1 plant in the Virgin Islands. Most of these plants were of relatively small size, with only 13 reporting an annual production exceeding

100,000 tons. By source, 59% was produced at 84 refineries or satellite plants treating refinery gases and 3 coking plants, and 41% was produced by 28 companies at 70 natural gas treatment plants. The five largest recovered sulfur-producing companies in 1987 were Chevron U.S.A. Inc., Exxon Co. U.S.A., Shell Oil Co., Standard Oil Co. (Indiana), and Texaco Inc. These companies' 60 plants accounted for 63% of recovered elemental sulfur output during the year.

A full year of production from Exxon's La Barge gas plant was responsible for pushing Wyoming sulfur output over 1 million tons for the first time. Texas continued to lead all other States in recovered elemental production and accounted for one-fourth of all recovered sulfur shipments.

Table 2.—Production of sulfur and sulfur-containing raw materials in the United States

(Thousand metric tons)

	1986		1987	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	4,043	4,043	3,202	3,202
Recovered sulfur[1]	5,816	5,816	6,161	6,161
Byproduct sulfuric acid (100% basis) produced at copper, lead, molybdenum, and zinc plants	2,811	919	3,069	1,005
Other forms[2]	767	309	445	173
Total	XX	11,087	XX	10,539

XX Not applicable.
[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes hydrogen sulfide, liquid sulfur dioxide, and pyrites.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand metric tons and thousand dollars)

Year	Production			Shipments	
	Texas	Louisiana	Total[1]	Quantity	Value[2]
1983	1,915	1,286	3,202	4,111	414,210
1984	2,527	1,207	4,193	5,001	546,106
1985	2,940	2,071	5,011	4,678	573,570
1986	2,462	1,579	4,043	4,108	508,512
1987	1,933	1,269	3,202	3,610	386,934

[1]Data may not add to totals shown because of independent rounding.
[2]F.o.b. mine.

Table 4.—Recovered sulfur produced and shipped in the United States[1]

(Thousand metric tons and thousand dollars)

Year	Production			Shipments	
	Natural gas plants	Petroleum refineries[2]	Total	Quantity	Value[3]
1983	2,971	2,584	4,955	5,041	384,214
1984	2,607	2,807	5,214	5,210	416,979
1985	2,973	2,940	5,813	5,288	485,084
1986	2,246	3,570	5,816	5,796	533,702
1987	2,536	3,624	[4]6,161	6,180	492,138

[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes a small quantity from coking operations.
[3]F.o.b. plant.
[4]Data do not add to total shown because of independent rounding.

Table 5.—Recovered sulfur produced and shipped in the United States, by State

(Thousand metric tons and thousand dollars)

State	1986			1987		
	Production	Shipments		Production	Shipments	
		Quantity	Value		Quantity	Value
Alaska	320	341	36,452	319	319	30,825
California	634	629	50,564	658	670	59,764
Florida	80	80	W	72	72	W
Illinois	272	269	26,261	255	256	26,604
Louisiana	534	527	57,418	526	526	51,074
Michigan and Minnesota	158	153	13,068	152	153	12,648
Mississippi	702	707	79,297	778	780	70,279
New Mexico	48	46	3,621	46	46	3,970
North Dakota	106	104	7,043	126	127	8,000
Ohio	46	46	5,188	42	43	3,915
Pennsylvania	52	53	4,540	59	56	4,417
Texas	1,517	1,516	141,223	1,516	1,532	134,381
Wisconsin	2	2	117	W	W	W
Wyoming	684	676	33,517	1,010	1,015	48,629
Other[1]	558	545	63,963	591	576	61,648
Total[2]	5,816	5,798	553,762	6,161	6,180	492,136

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Arkansas, Colorado, Delaware, Indiana, Kansas, Kentucky, Montana, New Jersey, Utah, Virginia, Washington, Puerto Rico, the Virgin Islands, and data indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 6.—Recovered sulfur produced and shipped in the United States, by Petroleum Administration for Defense (PAD) district

(Thousand metric tons)

District and source	1986		1987	
	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	254	258	253	246
Natural gas	79	79	72	72
Total[1]	334	338	325	319
PAD 2:				
Petroleum and coke	715	712	603	603
Natural gas	107	106	128	128
Total	822	818	730	731
PAD 3:[2]				
Petroleum	1,930	1,818	1,961	1,986
Natural gas	1,385	1,390	1,336	1,320
Total[1]	3,315	3,208	3,296	3,306
PAD 4 and 5:				
Petroleum	769	708	806	818
Natural gas	673	725	980	1,004
Total[1]	1,443	1,432	1,806	1,822
Grand total[1]	5,816	5,798	6,161	6,180

[1]Data may not add to totals shown because of independent rounding.
[2]Includes Puerto Rico and the Virgin Islands.

Byproduct Sulfuric Acid.—Sulfur contained in byproduct sulfuric acid produced at copper, lead, molybdenum, and zinc roasters and smelters amounted to 10% of the total domestic production of sulfur in all forms. Eight acid plants operated in conjunction with copper smelters and eight were accessories to lead, molybdenum, and zinc smelting and roasting operations. The five largest acid plants accounted for 70% of the output, and production in five States was 87% of the total. The five largest producers of byproduct sulfuric acid were ASARCO Incorporated, Inspiration Consolidated Copper Co., Kennecott, Magma Copper Co., and Phelps Dodge Corp. Their eight plants produced 84% of the 1987 total.

Table 7.—Byproduct sulfuric acid[1] produced in the United States

(Thousand metric tons, sulfur content, and thousand dollars)

Year	Copper plants[2]	Zinc plants[2]	Lead and molybdenum plants[2]	Total	Value
1983	601	128	104	831	54,906
1984	736	145	81	962	59,096
1985	729	141	87	957	56,299
1986	755	124	40	919	54,164
1987	831	134	38	1,003	61,994

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrites concentrates.
[3]Excludes acid made from native sulfur.

Pyrites, Hydrogen Sulfide, and Sulfur Dioxide.—Contained sulfur in these products represented 2% of the total domestic production of sulfur in all forms. The total sulfur contained in these products was less than that in 1986. The leading producers were Chevron, Magma, Phelps Dodge, and Tennessee Chemical Co. Tennessee Chemical terminated pyrite-mining operations, began burning purchased sulfur for sulfuric acid production at its Copper Hill, TN, facility, and restarted its Augusta, GA, sulfur-based acid plant.

Table 8.—Pyrites, hydrogen sulfide, and sulfur dioxide sold or used in the United States

(Thousand metric tons, sulfur content, and thousand dollars)

Year	Pyrites	Hydrogen sulfide	Sulfur dioxide	Total	Value
1983	W	W	50	302	61,260
1984	W	W	45	283	62,584
1985	W	W	43	323	67,688
1986	W	W	W	309	51,475
1987	W	W	W	173	28,711

W Withheld to avoid disclosing company proprietary data; included in "Total."

TRENDS IN THE PRODUCTION OF SULFUR IN THE UNITED STATES

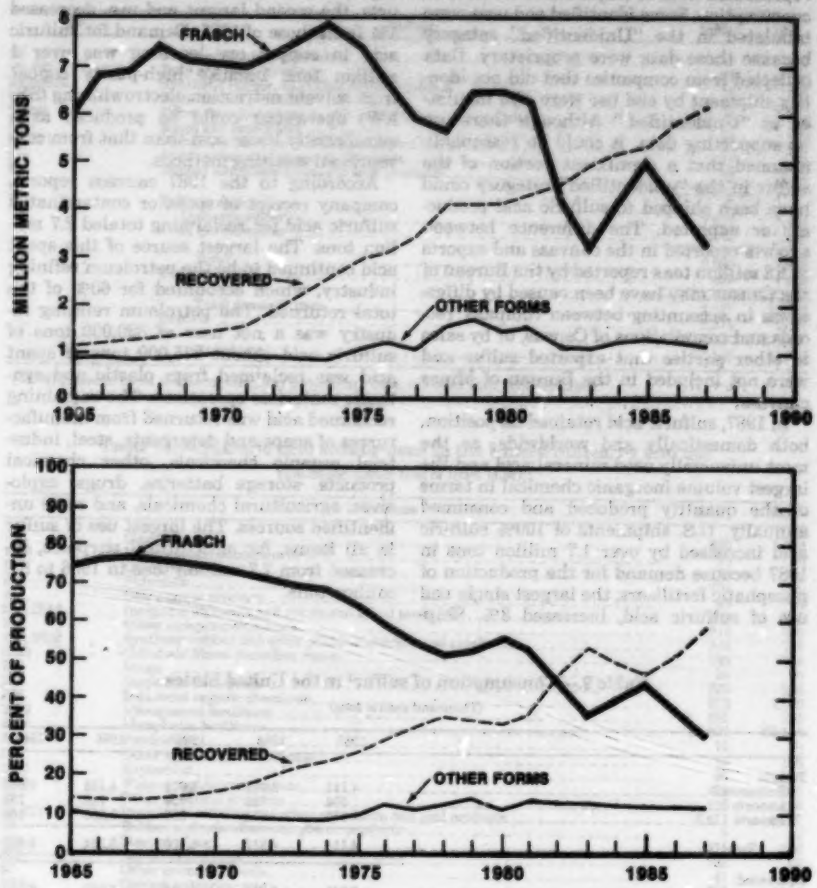

Figure 2.—Trends in the production of sulfur in the United States.

CONSUMPTION AND USES

Domestic consumption of sulfur in all forms increased 7% over that of 1986. In 1987, 86% of the sulfur was obtained from domestic sources, compared with 87% in 1986. The sources of supply were domestic recovered elemental sulfur, 48%; domestic Frasch sulfur, 28%; and combined domestic byproduct sulfuric acid, pyrites, H_2O, and SO_2, 10%. The remaining 14% was supplied by imports of Frasch and recovered elemental sulfur.

The Bureau of Mines collected end-use data on sulfur and sulfuric acid according to the Standard Industrial Classification of industrial activities. Shipments by end use of elemental sulfur were reported by 60 companies, and shipments of sulfuric acid were reported by 55 companies. Shipments of elemental sulfur and sulfuric acid were reported by 12 companies.

The largest sulfur end use, sulfuric acid, represented 87% of shipments for domestic consumption. Some identified end uses were tabulated in the "Unidentified" category because these data were proprietary. Data collected from companies that did not identify shipment by end use were also tabulated as "Unidentified." Although there are no supporting data, it could be reasonably assumed that a significant portion of the sulfur in the "unidentified" category could have been shipped to sulfuric acid producers or exported. The difference between exports reported in the canvass and exports of 1.2 million tons reported by the Bureau of the Census may have been caused by differences in accounting between company records and compilations of Census, or by sales to other parties that exported sulfur and were not included in the Bureau of Mines canvass.

In 1987, sulfuric acid retained its position, both domestically and worldwide, as the most universally used mineral acid and the largest volume inorganic chemical in terms of the quantity produced and consumed annually. U.S. shipments of 100% sulfuric acid increased by over 1.7 million tons in 1987 because demand for the production of phosphatic fertilizers, the largest single end use of sulfuric acid, increased 8%. Shipments of sulfuric acid for petroleum refining and other petroleum and coal products, the second largest end use, decreased 7% from those of 1986. Demand for sulfuric acid in copper ore leaching was over 1 million tons because high-purity copper from solvent extraction-electrowinning (SX-EW) operations could be produced at a significantly lower cost than that from conventional smelting methods.

According to the 1987 canvass reports, company receipt of spent or contaminated sulfuric acid for reclaiming totaled 2.7 million tons. The largest source of this spent acid continued to be the petroleum refining industry, which accounted for 60% of the total returned. The petroleum refining industry was a net user of 820,000 tons of sulfuric acid. About 875,000 tons of spent acid was reclaimed from plastic and synthetic materials operations. The remaining reclaimed acid was returned from manufacturers of soaps and detergents, steel, industrial organic chemicals, other chemical products, storage batteries, drugs, explosives, agricultural chemicals, and some unidentified sources. The largest use of sulfur in all forms, for agricultural purposes, increased from 7.7 million tons in 1986 to 8.2 million tons.

Table 9.—Consumption of sulfur[1] in the United States

(Thousand metric tons)

	1983	1984	1985	1986	1987
Frasch:					
Shipments	4,111	5,001	4,678	4,108	3,610
Imports	904	722	734	728	793
Exports	601	911	986	1,250	465
Total	4,114	4,812	4,416	3,584	3,938
Recovered:					
Shipments[2]	5,041	5,210	5,266	5,798	6,189
Imports	1,091	1,835	1,389	621	806
Exports	391	423	379	645	777
Total	5,741	6,622	6,267	5,774	6,209
Pyrites, shipments	W	W	W	W	W
Byproduct sulfuric acid, shipments	831	962	957	919	1,002
Other forms, shipments[3]	302	288	328	309	172
Total, all forms	10,988	12,679	11,968	10,586	11,323

W Withheld to avoid disclosing company proprietary data; included with "Other forms, shipments."
[1]Crude sulfur or sulfur content.
[2]Includes Puerto Rico and the Virgin Islands.
[3]Includes consumption of hydrogen sulfide, liquid sulfur dioxide, and data indicated by symbol W.

Table 10.—Elemental sulfur sold or used in the United States, by end use

(Thousand metric tons)

SIC	End use	1986	1987
20	Food and kindred products	W	W
26, 261	Pulp and paper products	21	32
282, 2822	Synthetic rubber, and other plastic products	W	W
287	Agricultural chemicals	551	541
28,286	Other chemical products and industrial organic chemicals	19	55
284	Soaps and detergents	22	26
29, 291	Petroleum refining and petroleum and coal products	92	180
281	Other industrial inorganic chemicals	76	80
30	Rubber and miscellaneous plastic products	W	W
	Sulfuric acid:		
	Domestic sulfur	7,017	7,420
	Imported sulfur	1,079	1,498
	Total	8,096	8,918
	Unidentified	620	409
	Total domestic uses	9,527	10,220
	Exports	1,511	1,127
	Grand total	11,038	11,367

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."

Table 11.—Sulfuric acid sold or used in the United States, by end use

(Thousand metric tons of 100% H_2SO_4)

SIC	End use	1986	1987
102	Copper ores	830	1,046
1094	Uranium and vanadium ores	98	85
10	Other ores	81	52
261	Pulpmills	701	740
26	Other paper products	48	62
285, 2816	Inorganic pigments and paints and allied products	362	380
281	Other inorganic chemicals	915	899
282, 2822	Synthetic rubber and other plastic materials and synthetics	766	773
2823	Cellulosic fibers, including rayon	138	140
283	Drugs	90	90
284	Soaps and detergents	232	244
286	Industrial organic chemicals	973	1,178
2873	Nitrogenous fertilizers	251	201
2874	Phosphatic fertilizers	21,330	22,116
2879	Pesticides	72	(1)
287	Other agricultural chemicals	80	108
2892	Explosives	93	150
2899	Water-treating compounds	371	301
28	Other chemical products	136	140
29, 291	Petroleum refining and other petroleum and coal products	2,617	2,427
30	Rubber and miscellaneous plastic products	9	12
331	Steel pickling	211	206
333	Nonferrous metals	103	93
33	Other primary metals	41	24
3691	Storage batteries (acid)	151	124
	Unidentified	1,480	1,316
	Total domestic	32,140	33,889
	Exports	36	44
	Grand total	32,176	33,933

[1]Included with "Other agricultural chemicals."

Table 12.—Sulfur and sulfuric acid sold or used in the United States, by end use

(Thousand metric tons, sulfur content)

SIC	End use	Elemental sulfur[1]		Sulfuric acid (sulfur equivalent)		Total	
		1986	1987	1986	1987	1986	1987
102	Copper ores	--	--	271	342	271	342
1094	Uranium and vanadium ores	--	--	32	28	32	28
10	Other ores	--	--	26	17	26	17
20	Food and kindred products	W	W	--	--	W	W
26, 261	Pulpmills and paper products	21	22	245	262	266	284
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products	[2]19	[2]55	119	118	138	173
281	Other inorganic chemicals	76	80	299	294	375	374
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	W	250	252	250	253
2823	Cellulosic fibers, including rayon	--	--	45	46	45	46
283	Drugs	--	--	16	29	16	29
284	Soaps and detergents	52	28	76	80	128	106
286	Industrial organic chemicals	--	--	318	385	318	385
2873	Nitrogenous fertilizers	--	--	82	66	82	66
2874	Phosphatic fertilizers	--	--	6,973	7,556	6,973	7,556
2879	Pesticides	--	--	24	(3)	24	(3)
287	Other agricultural chemicals	551	541	26	35	577	576
2892	Explosives	--	--	30	49	30	49
2899	Water-treating compounds	--	--	121	98	121	98
28	Other chemical products	--	--	45	46	45	46
29, 291	Petroleum refining and other petroleum and coal products	92	180	855	793	947	973
30	Rubber and miscellaneous plastic products	W	W	3	4	3	4
331	Steel pickling	--	--	69	67	69	67
333	Nonferrous metals	--	--	34	31	34	31
33	Other primary metals	--	--	13	8	13	8
3691	Storage batteries (acid)	--	--	50	41	50	41
	Exported sulfuric acid	--	--	12	14	12	14
	Total identified	811	914	10,084	10,662	10,845	11,576
	Unidentified	620	403	484	430	1,104	833
	Grand total	1,431	1,317	10,518	11,092	11,949	12,409

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
[1]Does not include elemental sulfur used for production of sulfuric acid.
[2]No elemental sulfur used in inorganic pigments and paints and allied products.
[3]Included with "Other agricultural chemicals."

TRENDS IN THE CONSUMPTION OF SULFUR IN THE UNITED STATES

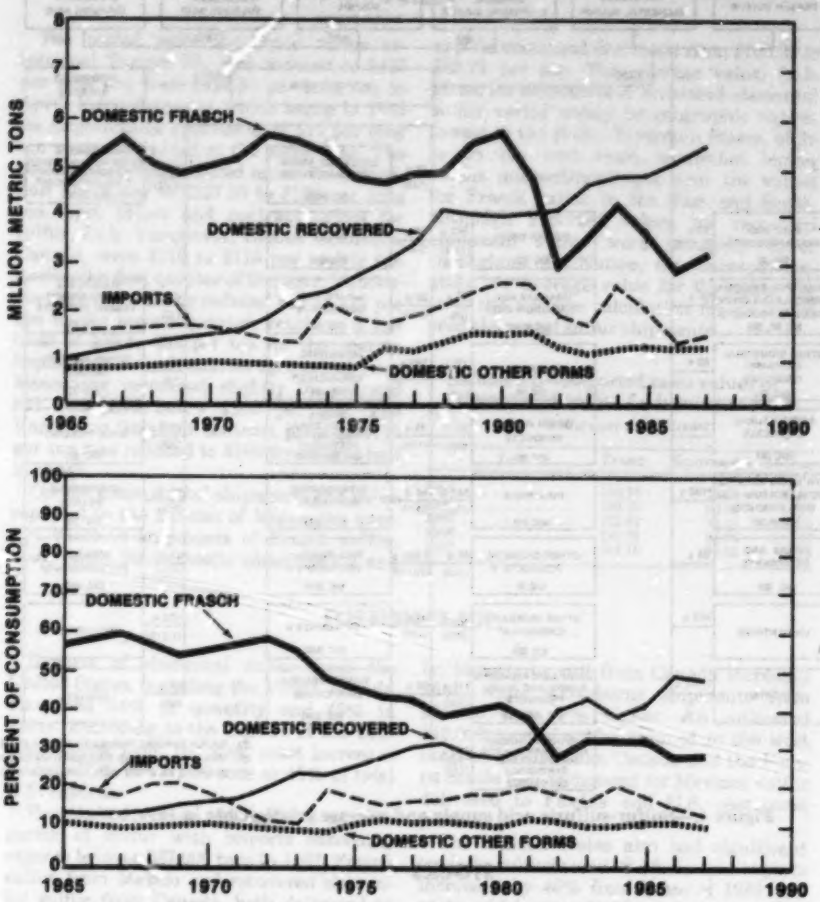

Figure 3.—Trends in the consumption of sulfur in the United States.

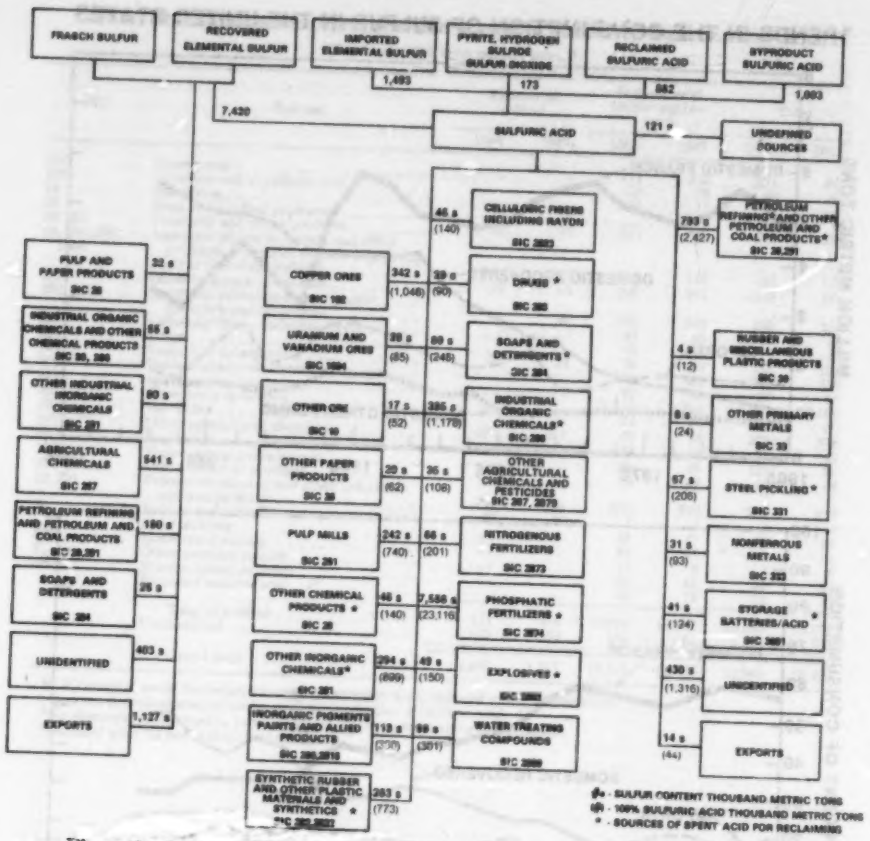

Figure 4.—Sulfur-sulfuric acid supply and end-use relationship in 1987.

STOCKS

Yearend inventories held by producers of Frasch and recovered elemental sulfur decreased 16%, after inventory adjustments, from those at yearend 1986. Combined yearend stocks amounted to approximately a 2.8-month supply compared with a 3.3-month supply in 1986, based on domestic and export demands for Frasch and recovered sulfur.

Table 13.—Yearend sulfur stocks of U.S. producers

(Thousand metric tons)

Year	Frasch	Recovered	Total
1983	3,070	153	3,223
1984	2,264	155	2,419
1985	2,598	201	2,799
1986	2,532	216	2,748
1987	2,122	194	2,316

PRICES

The posted price for liquid sulfur ex-terminal Tampa, FL, was reduced to $135 per long ton from $152.50 per long ton in April. Price discounts, which began in 1983 for large-volume customers, of $10 per long ton were eliminated at the same time. The posted price was reduced again for second-half purchases to $127.50 to $128 per long ton. Spot prices and contract prices for sulfur, f.o.b. Vancouver, British Columbia, Canada, were $110 to $115 per metric ton during the first quarter of the year. Vancouver spot prices were reduced $12 to $15 per ton in the second quarter, reaching a low level of $90 to $93 per ton for the year in September. Fourth-quarter spot prices from Vancouver recovered slightly by yearend but remained below $100 per ton. The Vancouver first-half contract price of $110 per ton was reduced to $100 for second-half loadings.

On the basis of total shipments and value reported to the Bureau of Mines, the average value of shipments of Frasch sulfur, f.o.b. mine, for domestic consumption and exports combined decreased from $105.22 to $89.78 per ton. The average value, f.o.b. plant, for shipments of recovered elemental sulfur varied widely by geographic region: lowest in the Rocky Mountain States, higher on the west coast, somewhat higher in the midcontinent, and near the values for Frasch sulfur in the East and South. Although reported values for recovered elemental sulfur were generally lower throughout the Nation, the disproportionately low average value for Wyoming distorts the average calculation for all recovered elemental sulfur shipments.

Table 14.—Reported sales values of shipments of sulfur, f.o.b. mine or plant

(Dollars per metric ton)

Year	Frasch	Recovered	Average
1983	100.76	76.22	87.24
1984	109.20	80.02	94.31
1985	122.32	92.11	106.46
1986	123.79	92.06	105.22
1987	107.15	79.65	89.78

FOREIGN TRADE

Exports of elemental sulfur from the United States, including the Virgin Islands, decreased 34% in quantity and 45% in value. According to the Bureau of the Census, exports from the west coast increased by over 25% to 577,000 tons or 46% of total U.S. exports.

The United States was again a net importer of sulfur with imports exceeding exports by over 357,000 tons in 1987. Frasch sulfur from Mexico and recovered elemental sulfur from Canada, both delivered to U.S. terminals and consumers in the liquid phase, continued to furnish nearly all U.S. sulfur import requirements. Total elemental sulfur imports increased 19% in quantity; imports by rail from Canada increased 26%, while waterborne shipments from Mexico were 9% higher. An estimated 540,000 tons of sulfur shipped to the west coast of Mexico from Canada and the United States was exchanged for Mexican sulfur delivered to Florida and U.S. east coast ports.

The United States also had significant trade in sulfuric acid. Sulfuric acid exports increased by 46% from those of 1986. Imports, which were significantly greater than exports, were mostly from Canada and increased slightly from the quantity reported in 1986. The value of imported sulfuric acid, however, decreased by over 17%.

Table 15.—U.S. exports[1] of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1986		1987	
	Quantity	Value	Quantity	Value
Algeria	22	2,990	--	--
Argentina	11	1,605	13	1,850
Australia	1	720	12	1,862
Belgium-Luxembourg	249	30,907	217	26,901
Brazil	188	28,880	258	31,532
Canada	19	1,116	15	1,386
Colombia	14	1,869	21	2,255

See footnote at end of table.

Table 15.—U.S. exports[1] of elemental sulfur, by country —Continued

(Thousand metric tons and thousand dollars)

Country	1986		1987	
	Quantity	Value	Quantity	Value
Egypt	40	4,585	--	--
France	11	1,335	25	2,574
India	66	8,642	85	8,409
Indonesia	53	6,839	24	2,332
Israel	25	3,533	(2)	5
Korea, Republic of	1	553	14	2,498
Mexico	139	13,768	222	20,736
Morocco	564	77,920	108	10,449
Netherlands	7	820	3	173
Romania	--	--	21	2,110
Senegal	56	7,101	48	5,127
South Africa, Republic of	19	2,808	26	2,575
Taiwan	49	6,590	23	2,402
Tunisia	322	42,215	64	6,948
Turkey	19	2,439	16	2,964
Uruguay	8	1,133	(2)	71
Other	r13	r3,775	24	5,207
Total[3]	1,895	251,664	1,242	139,431

rRevised.
[1]Includes exports from the Virgin Islands.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 16.—U.S. exports of sulfuric acid (100% H_2SO_4), by country

Country	1986		1987	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Canada	16,890	$680	27,686	$943
Chile	499	27	9,867	488
Costa Rica	589	40	1,557	86
Dominican Republic	382	63	263	44
Ecuador	144	16	5,044	220
Egypt	229	53	1,493	67
France	876	19	--	--
Japan	693	47	19	22
Korea, Republic of	1,208	848	1,973	991
Mexico	21,427	833	16,497	692
Namibia	1,495	60	--	--
Netherlands Antilles	6,400	320	8,966	371
Panama	3,613	193	2,920	128
Saudi Arabia	418	78	1,380	71
Taiwan	526	159	3,380	350
Trinidad and Tobago	38	5	803	34
United Kingdom	695	25	3,194	108
Venezuela	6,664	476	6,368	375
Other	r4,710	r679	6,535	855
Total	67,006	4,621	97,954	[1]5,844

rRevised.
[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 17.—U.S. imports of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1986		1987	
	Quantity	Value[1]	Quantity	Value[1]
Canada	605	50,342	764	52,048
Mexico	726	[r]79,709	793	94,444
Venezuela	16	4,891	41	4,897
Other[2]	(3)	278	1	708
Total	1,347	142,220	1,599	[4]152,096

[1]Declared customs valuation.
[2]Includes the Dominican Republic, France, the Federal Republic of Germany, and Japan in 1986; and Belgium, Chile, the Federal Republic of Germany, Japan, and Switzerland in 1987.
[3]Less than 1/2 unit.
[4]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 18.—U.S. imports of sulfuric acid (100% H_2SO_4), by country

Country	1986		1987	
	Quantity (metric tons)	Value[1] (thousands)	Quantity (metric tons)	Value[1] (thousands)
Belgium	16	$8	12	$42
Canada	589,174	20,511	715,008	22,284
Denmark	8,406	457	--	--
Finland	15,712	590	--	--
France	67	194	49	155
Germany, Federal Republic of	33,183	2,544	2	12
Italy	6,943	283	9,444	479
Japan	5	49	20,631	916
Netherlands	2,877	118	--	--
Spain	61,843	2,888	5,112	281
Sweden	21,583	828	2,281	348
Switzerland	596	381	3,600	171
United Kingdom	19,167	1,006	(2)	2
Other	[r]123	[r]46	08	70
Total[3]	759,702	29,883	766,210	24,760

[r]Revised.
[1]Declared c.i.f. valuation.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World sulfur production, consumption, and trade increased; however, international prices for elemental sulfur decreased. The U.S.S.R., which had imported over 800,000 tons of elemental sulfur from Canada in 1986, indicated early in the first quarter that it would not require more than 60,000 tons during 1987. Consumers of elemental sulfur, perceiving an oversupply condition in the international market, pressed for price reductions and other considerations from major exporters. Canadian exporters, faced with the loss of one-seventh of their export business, adopted an aggressive marketing stance and reduced prices f.o.b. Vancouver, British Columbia, Canada, by $12 to $15 per ton for deliveries beginning in the second quarter. Saudi Arabia reduced the "Government Expected Price," f.o.b. Jubail, $13 per ton to $100 per ton on April 1. In the highly competitive northern European market, liquid price quotes for the second half dropped about $20 per ton to $120 per ton. Second-half prices for liquid sulfur in the Tampa, FL, area were settled at $127.50 to $128 per long ton, a $15 decrease from January International prices in the $96 to $100 range, f.o.b. from Canada and Persian Gulf countries, effectively restricted U.S. Frasch exporters from many of their tradi-

tional markets; Frasch sulfur exports were reduced to the lowest levels since the early 1950's, when U.S. Government controls were in place.

Despite the perceived oversupply in the international marketplace, stocks of sulfur worldwide were reduced by nearly 700,000 tons. Stock levels were reduced by 1.4 million tons in Canada, and over 400,000 tons in the United States. Stocks increased in Iran, Iraq, Mexico, Saudi Arabia, and the U.S.S.R.

Canada.—Shipments of sulfur in all forms were about 7.98 million tons, or 1.41 million tons greater than production. Elemental sulfur exports increased in quantity by about 300,000 tons to nearly 6.57 million tons. The value of sulfur exports, however, decreased by over 20%. Canada remained the world's largest exporting country.

In February, Shell Canada Ltd. announced the discovery of a major new gas condensate field at Caroline, near Sundre, Alberta. The Caroline Field was the largest Albertan discovery in over a decade; gas reserves were estimated to be nearly 57 billion cubic meters with a hydrogen sulfide content 30% to 35%. Shell and its partners expected to begin development of the field and be producing over 1 million tons of sulfur by the early 1990's.

An October fire at Suncor Inc.'s Fort McMurray, Alberta, oil sands-bitumen extraction plant caused damages estimated at Canadian $50 to $60 million. Prior to the accident the facility was producing over 300 tons per day of elemental sulfur. Repairs were begun and full production is to be resumed by April 1988.

Canterra Energy Ltd. commissioned a cold flotation facility at its Ram River, Alberta, gas processing plant to recover contaminated sulfur from its block base pad. The company reduced its block inventory by several million tons during the 1980's and the 100,000-ton-per-year unit was to aid in recovering material not suitable for remelt.

Noranda Inc., in an agreement with the Federal and Provincial Governments, announced plans to construct a 350,000-ton-per-year sulfuric acid plant at its Horne copper smelter in Rouyn-Noranda, Quebec.[2] The acid plant was to reduce SO_2 emissions from the smelter by over 50%. Construction was to begin in 1988 with commissioning set for mid-1989.

Chile.—Misubishi Heavy Industries Ltd. of Japan began construction of a 600,000-ton-per-year sulfuric acid plant designed to recover exhaust gases from the Chuquicamata copper smelter. Corporación Nacional del Cobra de Chile contracted for the acid plant in 1986 to service its new flash smelter designed by Outokumpu Oy of Finland. Most of the acid plant's output was to be used to treat Chuquicamata's oxide zone copper ore in a heap leach, SX-EW system that was scheduled to recover 80,000 tons per year of copper by 1990.

China.—A new 3-million-ton-per-year pyrite mine was reportedly commissioned near Yunfu, Guangdong Province. China continued to explore for sulfur resources to augment production from pyrites for use in its program to increase fertilizer production from indigenous resources.

Egypt.—In November, Freeport Egyptian Sulphur Co., a subsidiary of Freeport-McMoRan Inc., reported a sulfur discovery near El 'Arish in the northern Sinai Desert.[3] A 140-foot interval containing sulfur was discovered at a depth of 1,200 to 1,340 feet. Further drilling was scheduled for the rest of the year and into 1988 to determine the size and extent of the deposit.

Iran.—Sulfur production remained below rated capacity of the nation's gas treatment facilities and petroleum refineries because of the ongoing war with neighboring Iraq. An estimated 150,000 tons of sulfur was put into inventories, and exports were estimated at 70,000 tons.

Iraq.—Sulfur exports continued to be routed overland through neighboring nations because safe passage could not be assured for Iraqi material in the Persian Gulf. Production was increased at the Mishraq Mine and from the Kurkuk gas plant. Freeport-McMoRan of the United States and the State Organization for Minerals discussed setting up a filtration plant, using Freeport technology, to treat production from the Mishraq Mine that had a high bitumen content.

Mexico.—Frasch sulfur production continued to increase and was scheduled to increase further with the commissioning of the Otapan Mine in 1988. Sulfur imports from Canada and the U.S. west coast were nearly 540,000 tons, which did not appear in official Mexican trade statistics. Most of these imports occurred by means of exchange agreements for deliveries of Mexican Frasch sulfur to the United States.

Construction began on a 600,000-ton-per-year sulfuric acid plant at Mexicana de Cobre S.A.'s La Caridad copper smelter. The

smelter operated with a high stack to disperse sulfur dioxide, but Mexico was obligated to install the acid plant as part of a 1985 agreement with the United States to limit emissions from Mexican smelters and Phelps Dodge's Douglas, AZ, smelter.

Morocco.—Morocco became the world's leading importer of elemental sulfur because of increasing consumption at its phosphate fertilizer facilities at Safi and Jorf Lasfar. Imports increased to nearly 2 million tons from 1.7 million tons and were projected to increase additionally by 500,000 tons in 1988-89 when the Jorf Lasfar facility was expected to become fully operational.

Poland.—Sulfur exports of 3.85 million tons included nearly 2 million tons to Eastern Europe and 915,000 tons to Western Europe. Most of the remainder was shipped to Brazil, India, and Morocco.

Saudi Arabia.—Sulfur production from natural gas processing plants and oil refineries increased slightly. Excess production of sulfur over domestic and export demand created a stock increase at the Berri gas plant of an estimated 500,000 tons.

U.S.S.R.—Production of elemental sulfur increased substantially because the new Astrakhan natural gas processing plant commenced operations. Output from the facility, which had four processing trains, was significantly less than the design capacity of 2.7 million tons per year. Each of the four trains had successfully been tested at full capacity during the year, and output at yearend was estimated to be nearly 4,000 tons per day. Construction of the second phase will double the size of the Astrakhan facility.

In November, it was announced in Moscow that Montedison S.p.A. of Italy and Occidental Petroleum Corp. of the United States signed an agreement with the U.S.S.R. to build and operate a petrochemical plant near the Tengiz oil-gas-condensate field. The facility was designed to produce 1 million tons per year of commercial sulfur. A separate facility under construction was planned to produce 450,000 tons per year of sulfur at Tengiz by 1989. The Tengiz Field had reserves of over 2.5 billion tons (18 billion barrels), making it one of the world's largest oil discoveries.[4] Production of oil from the field was scheduled to reach 30 million tons per year by 1995, which would yield 4.5 to 5 million annual tons of sulfur. By 1995, the total annual output of elemental sulfur from Tengiz and Astrakhan combined could be over 10 million tons.

Sulfur production from the Noril'sk nonferrous metallurgical center reportedly began late in 1987.[5]

Table 19.—Sulfur: World production in all forms, by country and source[1]

(Thousand metric tons)

Country[2] and source[3]	1983	1984	1985	1986[p]	1987[e]
Algeria: Byproduct, natural gas and petroleum[e]	15	20	20	20	20
Australia:					
Byproduct:					
Metallurgy	170	190	435	433	435
Petroleum	13	13	12	10	[e]9
Total	183	203	447	443	444
Austria:					
Byproduct:					
Metallurgy	9	10	11	11	11
Natural gas and petroleum	32	28	24	29	28
Gypsum	26	26	27	24	26
Total[e]	[r]68	[r]65	62	64	64
Bahamas: Byproduct, petroleum[e]	5	3	1	--	--
Bahrain: Byproduct, petroleum	49	[e]50	42	[e]45	45
Belgium: Byproduct, all sources[e]	250	240	250	260	250
Bolivia: Native	3	2	3	5	10
Brazil:					
Frasch	[r]3	4	4	6	6
Pyrites	[r]76	89	91	92	92
Byproduct:					
Metallurgy	[r]44	52	79	100	115
Petroleum	[r]65	71	55	74	75
Total	[r]188	216	229	272	288

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1983	1984	1985	1986[e]	1987[e]
Bulgaria:[e]					
Pyrites	80	75	65	80	80
Byproduct, all sources	66	62	53	62	65
Total	146	137	118	142	145
Canada:					
Pyrites[e 4]	9	(5)	(5)	(5)	--
Byproduct:					
Metallurgy	976	975	822	758	[4]803
Natural gas	5,300	5,300	5,296	5,161	[4]5,049
Petroleum[e]	170	181	[r]174	[r]189	190
Tar sands	290	296	393	435	[4]426
Total	[4]6,577	[r]6,596	[r]6,684	[r]6,543	6,468
Chile:					
Native:					
Refined	16	14	15	13	13
From caliche	62	40	64	44	44
Byproduct, metallurgy	32	32	30	41	40
Total	131	86	109	98	97
China:[e]					
Native	200	200	200	200	200
Pyrites	2,200	2,100	2,300	2,500	2,500
Byproduct, all sources	350	350	400	300	300
Total	2,850	2,670	2,900	3,100	3,100
Colombia:					
Native	31	36	41	36	40
Byproduct, petroleum	6	10	10	[e]10	10
Total	37	46	51	[r e]46	50
Cuba:[e]					
Pyrites	5	--	--	--	--
Byproduct, petroleum	8	8	8	8	8
Total	13	8	8	8	8
Cyprus:[e] Pyrites	21	10	31	25	25
Czechoslovakia:[e]					
Native	5	5	[4]5	6	6
Pyrites	60	60	[4]52	60	60
Byproduct, all sources	10	10	[4]12	10	11
Total	75	75	[4]69	76	77
Denmark: Byproduct, petroleum	[4]9	11	7	13	13
Ecuador:[e]					
Native	5	5	4	4	5
Byproduct:					
Natural gas	5	5	5	5	5
Petroleum	5	5	5	5	5
Total	15	15	14	14	15
Egypt: Byproduct, natural gas and petroleum[e]	1	[r]1	[r]3	[r]4	5
Finland:					
Pyrites	224	211	248	275	[4]311
Byproduct:					
Metallurgy	264	265	257	[r e]260	220
Petroleum	48	45	45	42	40
Total	536	521	550	577	571
France:					
Byproduct:					
Natural gas	1,653	1,589	1,298	946	872
Petroleum	157	163	[4]160	[e]180	200
Unspecified[e]	100	110	177	180	180
Total	1,910	1,862	1,722	1,306	1,252
Misc: Byproduct, all sources[e]	360	350	330	315	315

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1983	1984	1985	1986[r]	1987[e]
Germany, Federal Republic of:					
Byproduct:					
Metallurgy[e 6]	400	350	320	300	300
Natural gas	632	851	964	998	1,030
Petroleum[e]	195	190	200	190	210
Unspecified[e]	95	90	85	85	85
Total[e]	1,322	1,481	1,569	[r]1,573	1,625
Greece:					
Pyrites	67	78	[e]78	[r e]66	70
Byproduct:[6]					
Natural gas	115	120	130	130	130
Petroleum	[e]5	5	5	5	5
Total[e]	187	203	213	[r]201	206
Hungary:[6]					
Pyrites	2	2	2	1	1
Byproduct, all sources	9	9	9	10	10
Total	12	11	11	11	11
India:					
Pyrites	25	18	7	8	12
Byproduct:					
Metallurgy[6]	110	115	120	120	120
Petroleum	4	[e]5	(10)	[e]1	--
Total[e]	139	138	[r]127	[r]129	132
Indonesia:[6] Native	3	5	4	[e]4	4
Iran:					
Native[e]	20	30	30	30	30
Byproduct, natural gas and petroleum	16	130	150	[r e]250	300
Total[e]	36	160	180	[r]280	330
Iraq:[6]					
Frasch	300	500	500	600	610
Byproduct, natural gas and petroleum	40	70	70	[r]200	250
Total	340	570	570	[e]800	870
Israel: Byproduct, natural gas and petroleum[e]	10	10	10	[e]15	20
Italy:					
Native	9	8	1	--	--
Pyrites	271	192	280	309	300
Byproduct, all sources[e 11]	210	200	200	185	190
Total[e]	490	400	481	494	490
Japan:					
Pyrites	272	259	253	158	79
Byproduct:					
Metallurgy	1,239	1,191	1,291	1,228	1,215
Petroleum	1,102	1,142	1,044	985	927
Total	2,613	2,592	2,498	2,371	2,221
Korea, North:[6]					
Pyrites	200	200	200	200	200
Byproduct, metallurgy	30	30	30	30	30
Total	230	230	230	230	230
Korea, Republic of:					
Pyrites	(10)	(10)	--	--	--
Byproduct:[6]					
Metallurgy	54	54	55	55	55
Petroleum	36	36	35	35	35
Total[e]	90	90	90	90	90
Kuwait: Byproduct, natural gas and petroleum[e]	145	151	198	[e]280	350
Libya: Byproduct, natural gas and petroleum[e]	14	14	14	14	14

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1983	1984	1985	1986[p]	1987[e]
Mexico:					
Frasch	1,225	1,264	1,551	1,588	[4]1,806
Byproduct:					
Metallurgy[e]	160	160	160	[r]170	180
Natural gas and petroleum	377	461	469	462	[4]413
Total[e]	1,702	1,985	2,180	[r]2,220	2,399
Namibia: Pyrites	81	104	108	134	135
Netherlands:[e]					
Byproduct:					
Metallurgy	100				
Petroleum	105	245	250	250	245
Total	205	245	250	250	245
Netherlands Antilles: Byproduct, petroleum	87	63	[e]25	[e]40	35
New Zealand: Byproduct, all sources	1	1	[e]1	[e]1	1
Norway:					
Pyrites	179	[r]203	193	181	170
Byproduct:					
Metallurgy	[e]95	62	69	67	80
Petroleum	8	8	10	[r e]13	15
Total	282	273	263	261	265
Oman: Pyrites[e]	11	31	31	31	30
Pakistan:					
Native	1	1	1	1	2
Byproduct, all sources[e]	26	26	26	26	26
Total	27	27	27	27	28
Peru:					
Native	[10]	[10]	[10]	[10]	[10]
Byproduct, all sources	65	64	68	[e]66	66
Total	65	64	68	[e]66	66
Philippines:					
Pyrites	29	[r]39	108	113	[4]158
Byproduct, metallurgy[e]	57	95	100	120	140
Total[e]	86	[r]134	[r]208	[r]233	298
Poland:[e 12]					
Frasch	4,460	4,500	[4]4,386	4,400	4,500
Native	500	490	490	500	500
Byproduct:					
Metallurgy	170	170	170	170	170
Petroleum	30	30	30	30	30
Gypsum	20	20	20	20	20
Total	5,180	5,210	5,096	5,120	5,220
Portugal:					
Pyrites	124	140	155	144	140
Byproduct, all sources	5	4	[e]5	[e]5	5
Total	129	144	[e]160	[e]149	145
Qatar: Byproduct, natural gas	19	33	37	[e]37	35
Romania:[e]					
Pyrites	200	200	200	150	150
Byproduct, all sources	150	150	150	140	130
Total	350	350	350	290	280
Saudi Arabia: Byproduct, natural gas and petroleum	[r]793	833	1,100	[e]1,300	1,400
Singapore: Byproduct, petroleum	4	6	[e]5	[e]5	5
South Africa, Republic of:					
Pyrites	474	464	562	499	500
Byproduct:[e]					
Metallurgy	125	[4]91	[4]85	[r]108	110
Petroleum[13]	32	30	100	110	110
Total[e]	631	585	747	[r]717	720

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1983	1984	1985	1986[p]	1987[e]
Spain:					
Pyrites	1,073	1,094	1,231	1,195	1,000
Byproduct:[e]					
Coal (lignite) gasification	3	2	2	2	2
Metallurgy	120	125	115	105	110
Petroleum	8	9	7	8	8
Total[e]	1,204	1,231	1,355	1,310	1,120
Sweden:					
Pyrites	r219	r212	210	227	230
Byproduct:					
Metallurgy	114	122	123	125	125
Petroleum	20	26	23	49	50
Total	353	r360	356	401	395
Switzerland: Byproduct, all sources	3	3	3	3	3
Syria: Byproduct, natural gas and petroleum[e]	30	35	35	35	40
Taiwan: Byproduct, all sources	27	29	43	62	65
Trinidad and Tobago: Byproduct, petroleum[e]	8	7	5	5	8
Turkey:					
Native	35	41	44	41	40
Pyrites[e]	2	--	--	--	--
Byproduct, all sources[e]	75	78	80	80	80
Total[e]	112	119	r124	r121	120
U.S.S.R.[e]					
Frasch	800	800	850	875	950
Native	1,800	1,800	r1,800	r1,900	1,900
Pyrites	r2,700	r2,600	r2,500	r2,350	2,300
Byproduct:					
Metallurgy	r1,600	r1,700	r1,700	r1,700	1,650
Natural gas	r1,800	r1,850	r1,974	r2,000	2,300
Petroleum	450	450	450	450	450
Total	r9,150	r9,200	r9,274	r9,275	9,550
United Arab Emirates: Abu Dhabi:					
Byproduct:					
Natural gas	--	35	104	r90	90
Petroleum	10	15	1	r1	1
Total	10	50	105	r91	91
United Kingdom:					
Byproduct:					
Metallurgy	69	71	79	70	r64
Petroleum	55	75	80	105	110
Spent oxides	3	1	--	--	--
Total[e]	127	r146	149	175	174
United States:					
Frasch	3,202	4,193	5,011	4,043	r3,202
Pyrites	W	W	W	W	W
Byproduct:					
Metallurgy	831	962	957	919	r1,003
Natural gas	2,371	2,407	2,373	2,248	r2,536
Petroleum	2,584	2,807	2,940	3,570	r3,624
Unspecified	302	283	328	309	r173
Total[e]	9,290	10,652	11,609	11,087	r10,539
Uruguay: Byproduct, petroleum[e]	2	2	2	2	2
Venezuela: Byproduct, natural gas and petroleum[e]	85	86	88	90	92
Yugoslavia:					
Pyrites and pyrrhotite	298	301	323	344	r323
Byproduct:[e]					
Metallurgy	180	160	170	r175	175
Petroleum	3	3	3	3	3
Total[e]	481	464	496	r522	501
Zaire: Byproduct, metallurgy[e]	36	37	36	36	36

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1983	1984	1985	1986[p]	1987[e]
Zambia:					
Pyrites	[r]25	18	28	19	19
Byproduct, all sources[4]	80	90	80	80	80
Total[5]	[r]105	98	108	99	99
Zimbabwe:[6]					
Pyrites	25	25	25	25	25
Byproduct, all sources	5	5	5	5	5
Total	30	30	30	30	30
Grand total[5]	[r]49,770	[r]51,859	54,531	54,074	54,221
Of which:					
Frasch	[r]9,990	[r]11,361	12,982	11,512	11,694
Native	2,711	2,677	2,869	2,884	2,894
Pyrites	[r]9,054	[r]8,735	9,191	9,196	8,900
Byproduct:					
Coal (lignite) gasification	3	3	2	2	2
Metallurgy	[r]6,627	[r]6,919	7,105	7,101	7,187
Natural gas	[r]11,985	[r]12,150	12,280	11,613	12,247
Natural gas and petroleum, undifferentiated	[r]1,558	[r]1,839	2,181	2,679	2,982
Petroleum	[r]5,282	[r]5,856	5,784	6,433	6,463
Spent oxides	3	1	--	--	--
Tar sands	520	296	392	435	426
Unspecified sources	2,179	2,144	2,305	2,185	2,040
Gypsum	46	46	47	44	45

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Byproduct: Unspecified sources."

[1]Table includes data available through June 3, 1988.

[2]In addition to the countries listed, a number of nations may produce limited quantities of either elemental sulfur or compounds (chiefly H_2S or SO_2) as a byproduct of petroleum, natural gas, and/or metallurgical operations, but output, if any, is not quantitatively reported, and no basis is available for the formulation of reliable estimates of output. Countries not listed in this table that may recover byproduct sulfur from oil refining include Albania, Bangladesh, Brunei, Burma, Costa Rica, Guatemala, Honduras, Jamaica, Malaysia, Nicaragua, Paraguay, and Yemen-Aden. Albania and Burma may also produce byproduct sulfur from crude oil and natural gas extraction. No complete listing of other nations that may produce byproduct sulfur from metallurgical operations (including processing of coal for metallurgical use) can be compiled, but the total of such output is considered as small. Nations listed in this table that may have production from sources other than those listed are identified by individual footnotes.

[3]The term "source" reflects both the means of collecting sulfur and the type of raw material. Sources listed include the following: (1) Frasch recovery; (2) native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); (3) pyrites (whether or not the sulfur is recovered in the elemental form or as acid); (4) byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, tar sand cleaning, and processing of spent oxide from stack-gas scrubbers; and (5) recovery from the processing of mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded because to include it would result in double counting. It should be noted that production of Frasch sulfur, other native sulfur, pyrites-derived sulfur, mined gypsum-derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from tar sands are all credited to the country of origin of the extracted raw material; in contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which in some instances is not the original source country of the crude product from which the sulfur is extracted.

[4]Reported figure.

[5]Data may not add to totals shown because of independent rounding.

[6]Byproduct pyrite and pyrrhotite from the processing of metallic sulfide ores.

[7]Revised to zero.

[8]In addition, may produce limited quantities of byproduct sulfur from oil refining.

[9]Includes only the elemental sulfur equivalent of sulfuric acid produced as a byproduct from metallurgical furnaces; additional output may be included under "Byproduct: Unspecified sources."

[10]Less than 1/2 unit.

[11]Includes recovery from gypsum, if any.

[12]Official Polish sources report total Frasch and native mined elemental sulfur output annually, undifferentiated; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources.

[13]Estimates for 1985 and 1987 include byproduct production from synthetic fuels.

TECHNOLOGY

Monsanto Enviro-Chem Systems Inc. entered into an agreement with E. I. du Pont de Nemours & Co. Inc. to become the worldwide licensee for Du Pont's froth scrubbing technology for use in sulfuric acid applications. Monsanto, which designs and constructs sulfuric acid plants, believed that this technology was well suited to clean the exit gases from copper smelters and pyrites roasting plants prior to their introduction into the associated sulfuric acid plant. Monsanto stated that the advantages over conventional gas-cleaning facilities included lower capital and maintenance costs, high cleaning efficiency, lower energy requirements, and a simple reliable design with few moving parts. The 25% savings in energy consumption was especially attractive to copper smelting companies because of the reduced acid production costs.[6]

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[1]Physical scientist, Branch of Industrial Minerals.
[2]Canadian Mining Journal. Mar. 1988, p. 67.
[3]Sulphur. No. 194, Jan.-Feb. 1988, pp. 12-13.
[4]Fertilizer Focus. V. 5, No. 3, Apr. 1988, p. 4.
[5]Sotsialisticheskaya Industriya (Socialist Industry) Moscow). Oct. 8, 1987, p. 1.
[6]Fries, R. M., and R. M. Brendel, Monsanto Dynawave Scrubbers. Monsanto Enviro-Chem. Syst. Inc., St. Louis, MO.

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